Climate Change, Economic Growth, and Conflict

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Abstract

Despite many claims by high-ranking policy-makers and some scientists that climate change breeds violent conflict, the existing empirical literature has so far not been able to identify a systematic, causal relationship of this kind. This may either reflect de facto absence of such a relationship, or it may be the consequence of theoretical and methodological limitations of existing work. We revisit the climate–conflict issue along two lines. First, at the theoretical level we specify the mechanism through which climate change is likely to affect the risk of armed conflict. We focus on the causal chain linking climatic conditions, economic growth, and armed conflict, and also argue that the growth–conflict part of this chain is contingent on political system characteristics. Second, at the methodological level, we develop an approach that takes care of endogeneity problems in the climate–economy–conflict relationship. We test our theoretical argument on a global data set for 1950-2004. The results show that the climate change–conflict hypothesis rests on rather shaky empirical foundations: we do find some negative effects of climate change on economic growth, while stronger economic growth is associated with a lower probability of civil conflict. However, the climate change effect on growth is not robust to changes in climate indicators and samples. Our results also indicate that non-democratic countries are more likely to experience armed conflict when economic conditions deteriorate. Our results suggest that investing in climate-friendly economic growth and democracy can qualify as a no-regrets strategy.

Keywords: Climate change, economic growth, armed conflict, conflict, democracy

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Introduction

The assessment reports of the Intergovernmental Panel on Climate Change (IPCC, 2001; 2007), the Stern Review (2006), and many issue-specific studies demonstrate that human activity is contributing in important ways to climatic changes, and that those changes have far reaching effects on plants, animals, ecosystems, and humanity now and in the future. Among a wide range of negative effects, climate change tends to exacerbate the scarcity of important natural resources, such as freshwater, may trigger mass population dislocations (migration) due to extreme weather events, desertification and rising sea-levels, and may thus also increase the risk of violent conflict within and between countries.

The IPCC's 3rd and 4th Assessment Reports (IPCC, 2001; 2007) as well as a recent study by the German Advisory Council on Global Change (WBGU 2008), for example, refer to a possible link between climate change and violent conflict. The AR4 report, for instance, notes that climate change may become a major contributing factor to conflicts in the future particularly those concerning resource scarcity. Recent scientific work seems to support such statements. Burke et al. (2009: 20670) conclude:

We find strong historical linkages between civil war and temperature in Africa, with warmer years leading to significant increases in the likelihood of war. When combined with climate model projections of future temperature trends, this historical response to temperature suggests a roughly 54% increase in armed conflict incidence by 2030, or an additional 393,000 battle deaths if future wars are as deadly as recent wars.

High-ranking policy-makers have, on many occasions, also warned that climate change may contribute to armed conflict. For instance, UN Secretary-General Kofi

Annan stated in 2006 that climate change is a 'threat to peace and security'[1]; and his successor, Ban Ki-Moon, argued in 2007 that 'The Darfur conflict began as an ecological crisis, arising at least in part from climate change.'[2] US President Obama stated in 2009 that 'The threat of climate change is serious, it is urgent and it is growing…The security and stability of each nation and all peoples – our prosperity, our health, our safety – are in jeopardy. And the time we have to reverse this tide is running out.'[3]

In contrast to such quite unambiguous statements by some scientists and policy-makers, even a cursory review of the existing scientific literature reveals that there is rather little consensus on the climate–conflict relationship (for critical reviews, see Buhaug, Gleditsch & Theisen, 2008; Salehyan, 2008; Nordas & Gleditsch, 2007; Gleditsch, 1998). A better understanding of whether or not, and if so under what conditions climatic changes contribute to violent conflict is very important not only for scientific reasons, but also because of its policy-implications. If climatic changes do indeed contribute to violent conflict, this is (or perhaps would be) of course a powerful argument in favor both of drastic cuts of emissions of greenhouse gases and providing climate adaptation support to vulnerable countries, which are often also the poorest ones. The recent Himalaya glaciers episode of the IPCC reminds us, however, that we need robust scientific evidence when advocating costly policies. In addition, a better understanding of pathways leading from climate change to conflict (to the extent they exist) can help in avoiding or reducing, through appropriate policies, conflict-promoting effects of climate change.

We add to the existing literature on the climate–conflict relationship (e.g. Burke et al., 2009; Buhaug, Gleditsch & Theisen, 2008; Theisen, 2008; Raleigh & Urdal, 2007; Hendrix & Glaser, 2007; Reuveny, 2007; Salehyan, 2008) in at least two ways. First, while most of the existing literature empirically tests the climate–conflict hypothesis in the form of a direct relationship, we submit that climatic changes are likely to affect the potential for violent conflict primarily via negative effects on economic growth.

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1 Secretary-General Kofi Annan Address to the UN Climate Change Conference. http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=495&ArticleID=5424&l=en

2 *A climate culprit in Darfur*. The Washington Post. (http://www.washingtonpost.com/wp-dyn/content/article/2007/06/15/AR2007061501857.html)

3 US President Obama's Climate Change Speech at the UN General Assembly. http://www.undispatch.com/node/8898

Hence our theoretical argument specifies the causal pathway leading from climate change through economic growth to civil conflict, and our empirical analysis is designed to test this two-step causal argument. Second, we submit that political system characteristics, and notably democracy, can mediate conflict-promoting effects of sluggish economic growth. By implication, we argue that democratic systems are likely to be better equipped for avoiding violent conflict when climatic changes reduce economic growth.

The next section (section 2) reviews the relevant literature. We then develop the argument (section 3). In the fourth section we discuss the empirical approach, and then present the results in the subsequent section. Section 6 summarizes the findings and discusses their policy implications.

Literature Review

Climate change manifest itself with temperature increases[4], changes in precipitation, sea level rise[5], and the intensification of natural hazards, such as storms, floods, droughts, and landslides (IPCC, 2007). One major implication of global warming is greater scarcity and variability of renewable resources in many parts of the world (IPCC, 2001; 2007). With increasing concerns about such effects of climate change some scholars, commonly referred to as neo-Malthusians, posit that climate change is a security threat. For instance, Homer-Dixon suggests that environmental scarcity is at least in part responsible for some recent conflicts (e.g. violence in South Africa, insurgency in Assam, Zapatista rebellion in Chiapas) (Homer-Dixon, 1999; Percival & Homer-Dixon, 1998; Homer-Dixon & Blitt, 1998).

Arguments of this kind (e.g. by Homer-Dixon, 1999) posit that impaired access to renewable resources increases frustration among the affected individuals and social groups. Such frustration, in turn, creates grievances against the state, weakens the state and civil society, and increases the opportunity for instigating an insurrection. Building on this hypothesis, neo-Malthusian arguments then focus on two interrelated processes that are expected to exacerbate resource scarcity and competition over the means to sustain livelihoods. First, increasing temperature, precipitation anomalies

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4 The IPCC AR4 (2007) lists best estimates of +1.8 to +4.0^{0}C by 2090-2099 relative to 1980-1999. Global mean temperature has already increased by about 0.75 degrees over the past 100 years, with more warming in northern latitudes, and greater warming over land than over the oceans.

5 The IPCC AR4 (2007) lists a global mean sea-level rise of between 0.18 and 0.59 meters by 2090-2099 relative to 1980-1999.

and extreme weather aggravate processes of resource degradation that are already under way (e.g. WBGU, 2008; Kahl, 2006; Homer-Dixon & Blitt, 1998; Homer-Dixon, 1999). Second, more extreme weather conditions and other climate change implications, such as rising sea levels, force people to migrate. Such migration, in turn, can lead to greater pressure on resources in destination areas and to increased resource competition there (e.g. WBGU, 2008; Reuveny, 2007; Barnett, 1999; Homer-Dixon, 1999).

Other scholars, commonly referred to as cornucopians or resource optimists, do not share this pessimistic view. They acknowledge that environmental degradation may negatively affect human wellbeing. But they argue that humans can adapt to resource scarcity by using market mechanisms (pricing), technological innovation, and other means (Lomborg, 2001; Simon, 1998). Simon (1998) for instance notes that, although population growth can lead to shortages or increased economic burdens in the short run, the ability of society to respond to such circumstances by improvements in technology and efficiency usually outstrips the constraints imposed by an increasing population.

The neo-Malthusian argument has been criticized for being overly complex and deterministic, and for ignoring important economic and socio-political factors (e.g. Gleditsch, 1998; de Soysa, 2002a,b; Barnett & Adger, 2007; Salehyan, 2008). Critics have argued that scarcity of renewable resources is just one of the factors in the overall relationship between climate change and conflict. Buhaug, Gleditsch & Theisen (2008: 20) note that 'climate change may increase the risk of armed conflict only under certain conditions and in interaction with several socio-political factors'. They reject the idea that climate change has a direct effect on the likelihood of conflict and propose several causal pathways through which economic and political instability, social fragmentation, and migration could increase the probability of climate change leading to armed conflict.

Qualitative case studies (e.g. Baechler et al., 1996) provide some, albeit anecdotal evidence that climate change induced environmental degradation (such as water scarcity, soil degradation, or deforestation) has contributed to conflict in some parts of the world (e.g. the Sahel region). But it remains unclear to what extent these case-specific findings can be generalized. Large-N studies have, so far, not been able to provide conclusive evidence. One part of this variance in empirical evidence is certainly due to the use of different measures of climate change and environmental degradation, data problems, and different sample sizes and time periods. Another part, we submit, is due to the fact that past research has focused on identification of a direct link between climatic conditions and conflict. Conditional effects that stem from key factors such as economic development and the political system characteristics may thus have been overlooked.

Hauge & Ellingsen (1998) examine the effects of land degradation, freshwater scarcity, population density, and deforestation on intrastate conflict in the period 1980-1992. They find that all these factors have direct, positive effects on the incidence of conflict. Raleigh & Urdal (2007), using geo-referenced data for the sub-national level, study how factors presumably related to climate change, such as land degradation and freshwater availability, affected the likelihood of conflict in the period 1990-2004. They find that, whereas land degradation has a moderate to small effect on the incidence of conflict, local freshwater scarcity significantly increases the likelihood of conflict. This effect is stronger in low-income countries with higher population growth. Similarly, Theisen (2008) finds that only a high degree of land degradation increases the risk of intrastate conflict and concludes that 'scarcity of natural resources has limited explanatory power in terms of civil violence' (p. 810).

Hendrix & Glaser (2007) examine the impact of both long-term implications of climate change (land degradation and freshwater resources per capita) and short-term climatic changes (inter-annual variability in rainfall) on civil conflict onset in Sub-Saharan Africa in 1981-2002. They find that, while land degradation does not have any effect on the probability of conflict, local freshwater scarcity is positively associated with the likelihood of conflict. In addition, they report that positive changes in rainfall significantly decrease the conflict risk in the following year. Hendrix & Salehyan (2009) also investigate the effect of climate change, in particular rainfall and hydro-meteorological disasters (droughts and floods), on civil conflict as well as on civil unrest in Africa. They find that rainfall deviation increases the probability of civil conflict. They also observe, however, that droughts have no effect and floods even decrease the likelihood of conflict. Similarly, Theisen, Holtermann & Buhaug (2010) study the impact of climate change on the risk of civil conflict in Africa in the 1960-2004 period. They use geo-referenced data and several different drought measures, which they condition on various socio-political characteristics, such as politically marginalized population. They find little evidence that drought affects the likelihood of conflict. In contrast, Burke et al. (2009) find that temperature increases have a significant, positive effect on the occurrence of intrastate conflict in Africa. The studies mentioned in this paragraph are among the very few that use rainfall, temperature and natural hazards data, thus avoiding endogeneity problems associated with using indicators such as land degradation (see below). However, they still test for a direct relationship between climatic change and conflict, even though their theoretical arguments appear to favor an indirect relationship.

Zhang et al. (2007) hypothesize that climate change affects conflict through its effects on agricultural productivity. They examine the correlation among the components of the proposed pathway for the pre-industrialization period (1400-1900). Based on binary correlations, their findings suggest that changes in average temperature are strongly correlated with changes in agricultural production and the frequency of wars.

With the exception of several of the studies mentioned in the preceding paragraphs, many studies have used environmental degradation (e.g. water scarcity, soil erosion, land degradation) to explain conflict. These factors are very likely to be endogenous to human activity, in particular to economic development and the political system, which affects economic performance. Consequently, the causal effect may not only run from climatic conditions to economic conditions and then to conflict, but also in the opposite direction. In addition, several studies have shown that poor economic conditions may increase the probability of intra- and interstate conflict (Fearon & Laitin, 2003; Collier & Hoeffler, 2002, 2004), and such conflict may in turn increase the probability of recessions and affect economic growth (Schaffer, 2007; Blomberg, Hess & Thacker, 2006; Koubi, 2005). This two-directional effect may indeed create a poverty-conflict trap. Miguel, Satyanath & Sergenti (2004), for example, in a study of 41 African countries in 1981-1999, present evidence that negative deviations in annual precipitation (an instrumental variable for economic growth) substantially reduces national economic growth and thereby indirectly increases the probability of intrastate conflict. Hence it seems crucial not only to theoretically specify the exact pathway along which climate change is supposed to affect civil conflict but also to align the empirical analysis closely to the theoretical arguments.

Politically Moderated CEC (Climate Change–Economic Growth-Conflict) Relationship

In this paper we propose a politically moderated relationship between climatic conditions, economic performance, and conflict (CEC). Our theory builds on key findings of the scientific community: that climate change is indeed occurring, that human activity has clearly contributed to the problem, and that it has far reaching repercussions on ecosystems and humans alike. Nevertheless, we are not yet convinced that climate change directly increases the risk of armed conflict, though we readily agree that climate change has many other negative implications for what is commonly called human security (Adger, 2009).

As discussed in the preceding section, the existing scientific evidence on a potential climate-conflict relationship is still inconclusive. We believe that the inconsistency of existing findings arises at least partly because the empirical literature focuses on a direct relationship between climate change and conflict, and because it pays insufficient attention to conditional effects and endogeneity.

Our argument starts with the assumption that climate change manifestations *per se* are unlikely to trigger conflict either among states or among groups inside a state. However, given the empirical evidence discussed above we accept that changes in rainfall and temperature, coupled with volatile weather patterns swinging between extremes, have the capacity to reshape the productive landscape of entire regions and to exacerbate food, water, and energy scarcities, as envisaged in the traditional resource scarcity (neo-Malthusian) model. Consequently, we argue that climate change may, through its effects on economic growth, induce competition among groups inside a state. Hence it may thereby indirectly increase the likelihood of conflict. Violence, however, will occur only in states where the capacity for dealing with climate-induced economic deterioration and associated conflict potential is low. In particular, we submit that democratic institutions such as a constrained executive, a separation of power, a large number of veto players in public policy-making, and property rights collectively serve to strengthen the rule of law and thus mitigate conflict. The remainder of this section elaborates on the pathway through which climate change can, via its effects on economic conditions, lead to civil conflict.

Climate change and economic growth

The IPCC reports, the Stern Review, and many other studies point out that climate change has important, and in most cases negative effects on ecosystems and humans. However, estimating the consequences of climate change for economic growth, the relationship we are interested in at this point in the argument, is very tricky for various reasons. Climate and weather impact on almost all human activities from leisure to agriculture to industrial production. But even when considering only a few activities, for example agriculture or industrial output, the estimation task remains quite daunting. The main reason is that the impact of climate change will vary with levels of economic development and political capacity of a country, with levels and types of climate change (more/less rain; high/lower temperature; more/less frequent and/or intense storms, etc.). In other words: although economic and political actors will of course respond to climatic conditions by developing and implementing adaptation strategies, their ability to do so depends critically on institutional, economic, and technological capabilities.

The existing literature provides ample evidence that climate change affects economic output (GDP) (e.g. Mendelsohn et al., 1998; Mendelsohn, Dinar & Williams, 2006; Nordhaus & Boyer, 2000; Tol, 2002; Deschenes & Greenstone, 2007; Barrios, Bertinelli & Strobl, 2010). This also suggests that climate change should affect economic growth. If climate change affected only the level of economic output, for example by reducing agricultural yields when temperature rises (precipitation falls), this would imply that subsequent temperature decreases (precipitation increases) – due for example to stringent abatement of emissions – should return the GDP to its previous level. But this is not the case if climate change affects economic growth. The reasons are the following. First, economic growth will be lower even if GDP returns to its previous level because of forgone consumption and investment due to lower income during the period of higher temperature (lower precipitation). In addition, as long as countries spend some resources to adapt to climate change, they incur opportunity costs in terms of not spending these resources on R&D and capital investment. This has negative effects on economic growth. Moreover, given the shortness of the times series used in existing research on climate effects on economic conditions, even slightly persistent effects on the level of output will impact on the sample mean of growth. That is, using economic growth rates will also capture the effects on GDP levels. But using the level of GDP instead of its growth rate may miss the effects on the growth rate. For these reasons we concentrate on climate change effects on economic growth.

The empirical literature offers some evidence that climate change affects economic growth. For instance, Miguel, Satyanath & Sergenti (2004) find that rainfall growth increases economic growth in Africa. Dell, Jones & Olken (2008), using data on temperature and precipitation for a panel of 136 countries over the period 1950-2003, show that higher temperatures have large negative effects on growth, but only in poor countries, whereas precipitation has no effect. The authors also find that the estimated impact of temperature in poor countries is large – a 1^{o} C temperature increase reduces economic growth by 1.09 percentage points. In summary, we postulate, as supported by the literature, that climate change should have important negative effects on economic growth.

Economic growth and conflict

Previous research has shown that reduced levels of domestic economic activity tend to create incentives for increased conflict.[6] Drawing on this research, we posit that climate change, by reducing economic growth (that is, reducing the ability of the economy to grow), affects the utility of individuals and groups to engage in civil conflict. It does so in two ways.

First, negative climatic conditions, via their negative effect on economic growth, can reduce resources available to the government (e.g. by reducing tax revenue). The government thus has fewer resources to "invest in people", for instance to provide better nutrition, schooling, and on-the-job training that would lead to improved living conditions. It also has fewer resources to "provide for the people" in terms of sustaining peace through the maintenance of law and order – the latter, for instance, lowers the probability of rebel victory by increasing the cost of rebellion.

Second, climate related phenomena such as lower precipitation, higher temperature, and extreme weather events lead to lower personal income from production and also

[6] Chassang & Padro-i-Miquel, 2010; Garfinkel & Skaperdas 2007; Collier & Hoeffler, 2004; Fearon & Laitin, 2003; Skaperdas, 1992. See also Blattman & Miguel (2010) for a critical review of the literature.

decrease the opportunity for future employment. Consequently, the opportunity cost of rebellion decreases because the expected returns from peaceful employment, say farming, compared to joining criminal and insurgent groups are lower. In situations like these, when individuals expect to earn more from criminal or insurgent activity than from lawful and peaceful activity, predatory behavior becomes more likely. The latter implicates conditions in which each individual or group's effort to increase its own welfare reduces the welfare of others and also increases the probability of mutual attacks (Jervis & Snyder, 1999).

The argument that poverty breeds conflict and war is supported by several empirical studies (e.g. Hidalgo et al., 2010; Dube & Vargas, 2008; Hegre & Sambanis, 2006; Collier & Hoeffler, 2004; Fearon & Laitin, 2003). For example, Collier and Hoeffler (2004) find that low economic growth, which is a proxy for foregone earnings, has considerable explanatory power in their intrastate conflict regression. They conclude that rapid economic growth reduces the risk of conflict. Dube and Vargas (2008) examine whether violent actions in Colombia in the 1994-2005 period are linked to low opportunity costs of agricultural labor, using crop prices as a proxy for such costs. They show that a drop in the price of coffee substantially increased the incidence and intensity of intrastate conflict in coffee-intensive areas. They attribute this result to the lowering of opportunity costs of joining a rebel movement (via depressed wages) in coffee growing areas. Hidalgo et al. (2010), using a panel data set with over 50,000 municipality-year observations, show that land invasions by the rural poor in Brazil occur immediately after adverse economic shocks, which in the statistical analysis are instrumented by rainfall. Consequently, our argument that reduced economic growth can impact on the likelihood of civil conflict is well supported by the existing literature.

Political regimes/institutions and conflict

As discussed above, we expect the probability of violent conflict to increase when economic conditions deteriorate (whether due to climatic changes or for other reasons): individuals anticipate that their returns from labor diminish; and the ability of the government to provide goods and services for the people and to maintain order decays. This decreases the opportunity costs of engaging in political violence. We submit, however, that armed conflict is more likely to occur in states where existing institutions and mechanisms for conflict resolution cannot provide people with the assurance that climate change induced economic problems will be resolved without recourse to violence. Formal institutions that help to enforce commitments inter-temporally can mitigate commitment problems in situations in which each individual or groups' effort to increase its own wellbeing reduces the wellbeing of others.[7] We submit that democratic institutions that 'restrain the dark side of self-interest'[8], such as a constrained executive and separation of powers, an independent judiciary and courts, as well as the rule of law and secure property rights collectively work to reduce the risk of conflict. Conversely, societies with weak government institutions and few checks and balances are likely to be more prone to armed conflict. This implies that autocratic countries are more likely to experience intrastate conflict than democratic countries.

Studies on the relationship between political institutions and intrastate conflict have mostly focused on the effects of democracy and have thus far produced mixed results. Several studies find that democracy is not a good predictor of the probability of intrastate conflict (e.g. Collier & Hoeffler, 2004; Fearon & Laitin, 2003). Others (e.g. Hegre et al., 2001; Sambanis, 2001; Ellingsten, 2000; Reynal-Querol, 2002a,b) conclude that partly democratic countries (that is, semi-democracies, meaning regimes in the middle range of the democracy-autocracy Polity index) are more prone to intrastate conflict than full democracies and full autocracies. Elbadawi & Sambanis (2002) find that political instability (measured as regime change) increases the risk of intrastate conflict. But this effect diminishes at higher levels of democracy. Note, however, that these studies examine the direct effect of political institutions on

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7 See Powell (2006) on the commitment problem, and Jervis & Snyder (1999) on mutual fears and security.

8 See Skaperdas, 2008, 1992.

intrastate conflict, whereas our study concentrates on the interaction effect of economic growth and democracy on intrastate conflict.

Consequently, we argue that climate change may, through its effects on economic growth, induce competition among groups inside a state. Hence it may thereby indirectly increase the likelihood of conflict. Violence, however, will occur only in states where the capacity for dealing with climate-induced economic deterioration and associated conflict potential is low. In particular, we posit that democratic institutions such as a constrained executive, a separation of power, and a large number of veto players collectively serve to strengthen the rule of law and thus mitigate conflict.

Methods and Data

Most empirical studies on the poverty-conflict nexus do not adequately deal with the potential endogeneity of conflict to economic conditions, even though several studies show that conflict influences economic performance.[9] The work by Blomberg, Hess & Thacker (2006) provides strong evidence that conflict and the state of the economy are not independent of each other. Using panel data for over 152 countries from 1950 to 2000 they find evidence that recessions and poor economic performance increase the probability of intrastate and interstate conflict. They also show that conflict, in turn, increases the probability of recessions and lower economic growth. Many studies (e.g. Collier & Hoeffler, 2004; Fearon & Laitin, 2003) use lagged values of economic growth and per capita GDP, indicating thereby that the authors are aware of the endogeneity problem. Nonetheless, lagging these economic variables is not a fully convincing solution to the endogeneity problem since the anticipation of political instability and conflict can affect current investment behavior and thus living standards. Hence we opt for a two-stage least squares procedure.

Two-stage least squares approach

We test our argument on the climate change-economic growth-conflict relationship using panel data from all countries of the world in the time period 1950-2004. Potential endogeneity requires a system of equations rather than a single equation

[9] Sambanis ,2001; Blomberg & Hess, 2002; Miguel, Satyanath & Sergenti, 2004 are notable exceptions.

approach in order to properly test the politically moderated CEC relationship. Rather than using an instrumental variable approach merely as a technical solution, our theoretical considerations suggest that climate change may indirectly affect the probability of intrastate conflict via its effect on economic growth. For this reason we employ a two-stage procedure. While controlling for country characteristics we are less interested in (X_{it}), we use several indicators of precipitation and temperature change (ΔPre_{it}; $\Delta Temp_{it}$) to instrument per capita economic growth in the first stage of the model (subscript 1):

$$growth_{it} = \alpha_{1i} + \beta_{1,0}\Delta Pre_{it} + \beta_{1,1}\Delta Temp_{it} + c_1 X_{it} + d_1 year + e_{1it} \qquad (1)$$

We then estimate the effect of instrumented income growth on intrastate conflict in the second-stage equation (subscript 2) and introduce an interaction term between predicted growth and a country's political system:

$$conflict_{it} = \alpha_{2i} + \gamma_{2,0} growth_{i,t-1}\ (predict) + \gamma_{2,1} democracy_{i,t-1} + \gamma_{2,2} growth_{i,t-1}\ (predict) * democracy_{i,t-1} + c_2 Z_{it} + d_{2,1}\, peaceyears + d_{2,2}\, peaceyears^2 + d_{2,3}\, peaceyears^3 + e_{2it} \qquad (2)$$

Equation (1) is estimated using the fixed effects vector decomposition (fevd) estimator by Plümper & Tröger (2007). This estimator allows us to include time invariant variables alongside country fixed effects. Furthermore, we use panel-corrected standard errors (PCSE) to control for panel heteroskedasticity (Beck & Katz, 1995), a Prais-Winsten specification to correct for autocorrelation, and we include a time trend.

Equation (2) is estimated using logit regression with bootstrapped standard errors. To model temporal dependence, time since the last conflict as well as it's squared and cubic term (peaceyears, peaceyears^2 and peaceyears^3) are included in the model (Carter & Signorino, 2009). This approach acknowledges that the likelihood of intrastate conflict onset today depends strongly on conflict occurred in the years before and thus controls for time effects. The use of peaceyears, peaceyears^2 and peaceyears^3 (cubic time polynomial) instead of cubic splines (as proposed by Beck, Katz & Tucker, 1998) has the advantage of a more straightforward interpretation of the baseline hazard, whereas the approximation of the baseline hazard is at least as good as with cubic splines (Carter & Signorino, 2009).[10]

Variables and Data Sources

Economic growth (growth):

The dependent variable in the first equation is economic growth. We use data from the Penn World Tables (Heston, Summers & Aten, 2006).

Onset of Civil Conflict (conflict):

We use data on civil conflict onset from the Onset of Armed Conflict Dataset, a joint project of the Department of Peace and Conflict Studies, Uppsala University, and the Center for the Study of Civil War at the International Peace Research Institute, Oslo (Gleditsch et al., 2002; Strand, 2006). An armed civil conflict is defined in the Uppsala/PRIO database as a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which one is the government of the state, results in at least 25 battle-related deaths. We use the onset variable that specifies a nine-year intermittency threshold. This implies that for any new conflict onset to occur the country could not have had any conflict within the last nine years.

This indicator of civil conflict obviously captures only a particular form of political violence, namely events in which the government is directly involved on one side and at least 25 persons are killed. Efforts to collect data on communal (non-state) violence and social unrest are currently in progress, but such data is not yet available for a large number of countries and a sufficiently long time-period. In other words, the chosen indicator does not capture all forms and levels of political violence, but it measures an important and severe form of political violence, which figures prominently in the debate on the climate-conflict nexus.

[10] Another possibility would be to use the estimator proposed by Maddala (1983), which is designed to test a two-equation system with a dichotomous endogneous variable (see also Keshk, 2003). In difference to the approach described by Maddala (1983), we need to incorporate in the second equation the interaction effect between democracy and the predicted values for economic growth from the first equation. Doing so in the context of Maddala's approach is, however, not straightforward, which is why we opted for the procedure described above.

Climate change (Precipitation, Temperature):

We use the annual variation in precipitation and temperature as indicators of climate change to estimate the impact of economic growth on the probability of conflict onset. This approach has two advantages.

First, it avoids an endogeneity problem that is plaguing much of the literature on the neo-Malthusian hypothesis. Many of the empirical studies discussed above use environmental degradation, such as water scarcity, soil erosion, and land degradation, as explanatory variables.[11] These phenomena are, obviously, not exogenous to human activity. If we used such indicators in our analysis we would have to deal with endogeneity in both stages of the estimation, which would be a daunting task indeed. Because climate change is a global phenomenon that is largely beyond human control at the local level within the short to medium term, using changes in precipitation and temperature avoids the endogeneity problem.

The second advantage derives from the fact that, geophysically, temperature and precipitation are quite directly linked to changes in greenhouse gas concentrations, whereas other environmental phenomena (e.g. reduced water availability, soil degradation) are consequences of human-induced and natural climatic changes as well as human activity directly impacting on natural resources. By using temperature and precipitation we avoid having to deal with a plethora of complex environmental, health and other implications of temperature and precipitation changes that then affect economic growth. In other words, our approach helps in avoiding statistical problems associated with endogeneity, and it helps at the conceptual level in setting up and testing a rather parsimonious model that is tightly connected to our theoretical argument.

We use three different measures of precipitation and temperature variation and rely on two different data sources. First, we use the Standardized Precipitation Index, SPI 6. This is a standardized probability index that measures variation in precipitation. The SPI 6 indicates the monthly deviation from normal rainfall during the six preceding months. Negative values indicate a period of drought and positive values indicate wet

[11] This statement does not imply a criticism of that literature because many authors have not been interested in climate change implications per se, but rather in the security implications of environmental degradation.

conditions (McKee et al. 1993).[12] Following Theisen, Holtermann & Buhaug (2010), we aggregate the monthly SPI 6 measures by creating a dummy variable that takes the value of 1 if at least three consecutive months have an SPI smaller than -1, which corresponds to weather conditions equivalent to a moderate drought or worse (McKee, Doesken & Kleist ,1993), and 0 otherwise.

We also use the yearly moving average both of precipitation and temperature. This variable captures the difference between the current year's precipitation (temperature) level and the average of the previous 30 years. As a robustness check we also use the annual growth rate in precipitation (temperature)[13] (see Table A.I and A.II in the Appendix). Our data sources are the Global Precipitation Climatology Centre (GPCC), CRUTEM3 (Brohan et al., 2006), and the Climatic Research Unit (CRU) (Mitchell, 2004).

Political institutions (xpolity):

Our indicator for democracy is based on the combined Polity score from the Polity IV dataset. Polity assigns scores to democracy according to three elements: competitiveness of executive recruitment (XRCOMP), openness of executive recruitment (XROPEN), and competitiveness of participation (PARCOMP). The competitiveness of participation element makes explicit reference to civil conflict. We thus use the xpolity data by Vreeland (2008), which excludes the participation dimension of the original polity IV data. The original data are from the POLITY IV project (Marshall & Jaggers, 2004).

To capture the interaction effect between a country's political institutions and predicted growth in the second equation, we introduce an interaction term between the two variables into our model.

Control variables:

GDP per capita and initial per capita income (log gdp/capita, GDP_initial):

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12 More precisely, the SPI is the number of standard deviations that the observed value would deviate from the long-term mean.

13 That is ($Precipitation_{it}$ - $Precipitation_{i,t-1}$)/ $Precipitation_{i,t-1}$ and (($Temperature_{it}$ - $Temperature_{i,t-1}$) / $Temperature_{i,t-1}$). This measure is used by Miguel et al. (2004).

Since income convergence plays a key role in all economic growth theories and is always included in empirical studies of economic growth, we use the initial real income to capture convergence factors. In addition, we include the lagged value of the log of GDP per capita to control for the stylized fact that poverty breeds conflict, that is, the hypothesis that civil conflict is observed mostly in poor countries. We use data from Gleditsch (2002), which is an updated version of the Penn World Tables.

Population (log population, pop growth):

We include population size and population growth because population is considered to be an important determinant of civil conflict (North, 1984; Homer-Dixon, 1994; Hegre & Sambanis, 2006). For example, North (1984) claims that a growing population creates an increasing demand for resources and concludes that states with high population growth and inadequate resources are more conflict prone. Fearon & Laitin (2003) also argue that a large population implies difficulties in controlling local level activity and increases the number of potential rebels that can be recruited by the insurgents. Homer-Dixon (1994)'s argument that population pressure coupled with resource scarcity leads to intrastate conflict is empirically supported by Urdal (2005). Urdal observes that high population growth in combination with scarcity of utilizable land increase the likelihood of civil conflict. Simon (1998), however, posits that as long as population growth stimulates advances in technology, the economic motivation for territorial expansion will diminish and wars driven by population growth may be less common in the future. We use data from Gleditsch (2002).

Ethnolinguistic fractionalization (ethnic fractionalization):

Although there is disagreement in the literature on the relationship between the heterogeneity of a country's population and the country's propensity for intrastate conflict (e.g. Fearon & Laitin 2003; Cederman & Girardin 2007), we account for the possibility that ethnolinguistic fractionalization affects the potential for civil conflict. Elbadawi & Sambanis (2002), for instance, find that socially diverse societies may be at somewhat higher risk of civil conflict, whereas Fearon & Laitin (2003) do not find a statistically significant relationship. However, Theisen, Holtermann & Buhaug (2010) find that climate change is more likely to cause conflict in areas dominated by politically marginalized ethnic groups than in areas of ethnic group dominance. We use data from Fearon & Laitin (2003).

Rough terrain (mountainous terrain):

Fearon & Laitin (2003) argue that mountainous countries are likely to experience a higher risk of civil conflict because rebels find it easier to hide in mountains and forests. They find a statistically significant relationship between rough terrain and civil war onset, whereas a similar analysis by Collier & Hoeffler (2004) does not support this hypothesis. We control for this potential effect, measuring rough terrain by the estimated percentage of mountainous terrain and using data from Fearon & Laitin (2003).

Oil exporting countries (oil):

Proponents of the 'resource curse' argument claim that the geographically concentrated abundance of some specific, globally scarce and thus precious natural resources (e.g. oil, diamonds, coltan) contributes to civil conflict.[14] They argue that income from exploiting such resources may be used to fund insurgent activity, and that distributing the rents from such resources can produce conflict. Empirical testing of this hypothesis has, thus far, produced mixed results. Some studies have found evidence supporting the resource curse claim (e.g. Collier & Hoeffler, 2004; Ross, 2004; de Soysa, 2002a, b; Le Billion, 2001). Others, such as a study by Brunnschweiler & Bulte (2008), find that resource abundance tends to promote economic growth and decrease the risk of civil war. In respect to the economically most important non-renewable natural resource globally, namely oil, several authors have argued that civil conflict is more likely in oil producing countries. The reason is that 'oil revenues raise the value of the "prize" of controlling state power' and oil exporting countries tend to have weaker state apparatuses (Fearon & Laitin 2003: 81). To control for this possibility we include an indicator for countries in which oil constitutes more than one-third of export revenues. We use data from Fearon & Laitin (2003).

Regional dummy variables and time trend:

We include regional dummy variables, with Europe serving as the baseline category, to control for any regional variation in both economic growth and conflict. We also introduce a linear time trend in the model to explain economic growth.

[14] The neo-Malthusian and resource curse arguments are, in contrast to a common misconception, not in contradiction. The former concentrates largely on renewable natural resources, whereas the latter focuses on non-renewable natural resources. In the resource curse argument, conflict is fueled by the geographically concentrated (and not the general) abundance of a globally scarce resource that offers high economic profit margins for those who exploit it.

Descriptive statistics are shown in the Appendix.

Results

Table I reports the results from the regression of income growth on climate change and the control variables described above. It does so for two samples: all countries and African countries only.

We conduct a separate analysis for Africa because much of the existing literature focuses on Africa (and often on Sub-Saharan Africa only). The reason for focusing on Africa is that agriculture is the most important sector in these economies and a high percentage of the population lives in rural areas. At the same time, water storage capacity (dams, reservoirs) and the percentage of irrigated land in Africa are the lowest in the world, which, in combination with low economic and state capacity, is likely to make these countries more vulnerable to changes in precipitation. African countries also experience more frequent civil conflict than other parts of the world. Hence they constitute critical cases. That is, if we cannot detect a climate change effect on civil conflict in Africa such an effect is, presumably, unlikely to exist in other parts of the world (e.g. Burke et al., 2009). We think that this justification sounds plausible, but also think that an explicit empirical test is better, notably because agriculture is also important in other regions of the world, for example in Asia and Latin America, and because climate change in other regions is also occurring.

Table I in here

The results show that the impact of climate change on economic growth depends on how we operationalize climate change and which sample we use. The SPI 6 index has no effect, neither in the global nor the African sample (models (1) and (2)). In contrast, the moving average-based measure of temperature has a statistically significant, negative coefficient in the African sample (column (4)) – meaning that higher temperatures are associated with less economic growth. Although this negative effect of temperature change on growth in African countries supports the theoretical expectation, the effect is not very robust (significant only at the 10% level).

Interestingly, neither democracy nor population growth have a statistically significant effect on economic growth. The estimated coefficients of the other explanatory variables are statistically significant (except for ethnic fractionalization in models (1) and (4)) and are very similar to those reported in the economic growth literature (e.g. Barro & Lee, 1994).

Table II reports the results from the regression of civil conflict onset on the instrumented economic growth.

Table II in here

Because we use a multiplicative term of lagged predicted growth and lagged democracy, the main effect of interest in this regression is best understood by means of a graphical illustration. Figure 1 shows the coefficients of predicted (instrumented) economic growth on the likelihood of conflict onset at different values of the democracy variable. If the vertical lines, which show the confidence intervals of the respective point estimate, do not cross the zero line, the coefficient on predicted economic growth is significant for the respective value of the democracy variable. Figure 1 shows that predicted economic growth has a statistically significant effect on civil conflict onset in less democratic countries (notably those with a Polity score of 0 or less), but not in democracies. Figure 2 confirms this result, using the moving average instead of the SPI 6 in the first equation. Hence the results for the second stage of the statistical model support our theoretical argument that economic growth has an effect on civil conflict primarily in non-democratic countries.

Figures 1 and 2 in here

As to the control variables, only population, the log of GDP per capita and oil have a consistent, positive, and statistically significant effect on conflict in the global sample. Ethnic fractionalization has a statistically significant, positive effect in model (1) only. Presumably due to the lower number of observations none of these variables has a significant effect in the African sample.

Robustness Checks

We have checked the robustness of our results using various other indicators of climate change (Tables A.I and A.II in the Appendix). Whereas other indicators of climate change have varying impacts on economic growth, most other results are similar to those shown in Tables I and II above.

In addition, we have tested the robustness of our results by looking at the direct effect of climate change on conflict instead of using the predicted values of climate change on economic growth only. Although, our theoretical arguments suggest that the influence of climate change on civil conflict should run only through economic growth, our results could be biased if we did not control for a direct climate effect in the second equation while there was indeed a direct effect. However, since the results do not support a direct effect of climate change on conflict, which is in line with, for example, Theissen, Holtermann & Buhaug (2010), we are confident that our results on the indirect effect of climate change via economic growth on civil conflict are unbiased.

The indicator of conflict used so far in our analysis includes all civil conflicts in which there are at least 25 battle related deaths. Another commonly used conflict threshold are 1000 battle related deaths. Tables A.V and A.VI in the Appendix show that the results do not change substantively if we rely on this more exclusive conflict measure. Only the indicator measuring whether more than one-third of a country's export revenues come from oil looses statistical significance.

Finally, we run our regression models on a sample including particularly poor countries, namely those defined as 'the bottom billion' by Collier (2007), using the same list of countries as Buhaug, Falck & Gleditsch (2010). The logic is that poorer countries are more vulnerable to climate change and should experience a greater risk of conflict due to lower capacity to adapt to negative effects of climate change on growth. Although we deal with the fact that the a priory vulnerability of a country to climatic changes varies using country fixed effects, we also address one of those vulnerability conditions by running robustness checks with two subsamples: Africa, and all poor countries. As in the main models presented above, we neither find a statistically significant effect of the SPI, nor of the moving average-based measure of climate change on economic growth.

Taken together, the results for the two stages of our model suggest that the climate change–conflict hypothesis rests on rather shaky empirical foundations. We do find some statistically significant, negative effects of climate change on economic growth, while stronger economic growth is associated with a lower probability of civil conflict. But the climate change effect on economic growth strongly depends on the particular climate indicator used, and on whether we include all countries or only African countries in the analysis.

Conclusion

This paper contributes to the literature on the climate change–conflict nexus along two lines. First, it conceptualizes this nexus in terms of a two-stage process in which climatic changes affect the probability of armed conflict via climate effects on economic growth. In addition, we view the effect of economic growth on conflict as contingent on political system characteristics. Second, the paper develops an empirical testing strategy that takes into account endogeneity problems in this two-stage process.

Our results provide rather little support for the climate change–conflict hypothesis. By implication, it appears unlikely that climate change will reverse the downward trend in civil conflict within the past decade. Does this mean we should bury this hypothesis, and that policy-makers have nothing to learn from existing research on this issue? We submit that the answer to both parts of the question should be NO.

To begin with: even if all existing and future research were to show that climatic changes do not increase the risk of civil conflict, there are plenty of other strong justifications associating climatic changes with other types of very serious climate effects on ecosystems and human security. In other words, even though climate-induced risks of civil conflict could potentially provide a powerful justification for greater investment in mitigation and adaptation efforts, climate policy can easily be justified with other reasons. The recent problem with the IPCC's poorly founded predictions concerning melting of the Himalaya glaciers should also serve as a warning that justifications for costly policies should not be pushed without robust scientific support.

We also submit that it would be premature to conclude from our results that climate change has no effect on economic growth and therefore, by implication, no effect on the risk of civil conflict. The enormous literature on the determinants of economic growth shows that variation in growth is very hard to explain as such. Hence it would have been surprising indeed if we had been able to identify a very strong impact of climatic changes on growth alongside the many other factors that affect growth – though we did of course find negative effects of some climate change indicators on growth. However, it seems likely that much bigger changes in temperature and precipitation, compared to those observed in our sample period, which are predicted for many parts of the world in the next decades, will make it harder for countries to adapt. If so, negative growth effects of climatic changes are likely to become more visible within the foreseeable future.

In view of our results for the growth–conflict relationship and its contingency on democracy, one of the policy implications of our findings is that investing in measures that promote economic growth (preferably in a climate-friendly way), democracy, and non-violent conflict resolution can qualify as a no-regrets policy. Even if climatic changes ultimately turn out to have no conflict promoting effect, investing in such measures is likely to have a conflict reducing effect. And if climatic changes do turn out to have a conflict increasing effect, countries with greater economic capacity and democratic institutions are likely to have a superior capacity to avoid or escape the climate change–poverty–conflict trap.

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Table I. Climate Change and Economic Growth

	(1) world, SPI	(2) africa, SPI	(3) world, gpcc ma	(4) africa, gpcc ma
SPI	-0.403	-0.590		
	(0.407)	(0.880)		
temperature ma30			-0.203	-0.856
			(0.189)	(0.475)*
precipitation ma30			0.000	0.002
			(0.001)	(0.002)
xpolity, lagged	-0.044	-0.026	-0.036	0.008
	(0.029)	(0.080)	(0.033)	(0.076)
pop growth	13.096	28.714	15.965	48.524
	(9.077)	(29.063)	(15.011)	(53.879)
log population, lagged	-7.102	-6.456	-4.613	-4.933
	(0.617)***	(2.667)**	(0.690)***	(3.317)
log gdp/capita, lagged	-5.913	-5.843	-5.417	-5.579
	(0.663)***	(1.165)***	(0.960)***	(1.967)***
trend	0.211	0.170	0.158	0.146
	(0.021)***	(0.072)**	(0.029)***	(0.103)
oil	3.726	6.388	2.925	4.845
	(0.385)***	(0.641)***	(0.574)***	(0.391)***
ethnic fractionalization	-0.777	2.282	-2.237	-2.093
	(0.483)	(1.046)**	(0.606)***	(1.313)
mountainous terrain	0.601	1.680	0.265	1.471
	(0.060)***	(0.123)***	(0.065)***	(0.105)***
GDP initial	0.000	0.002	0.000	0.002
	(0.000)	(0.000)***	(0.000)***	(0.000)***
North Africa	-5.283		-5.570	
	(0.270)***		(0.182)***	
Sub Saharan Africa	-17.514		-14.109	
	(0.263)***		(0.429)***	
East Asia	-1.653		-2.165	
	(0.335)***		(0.151)***	
West Asia	-4.309		-5.247	
	(0.340)***		(0.185)***	
Middle East	-12.244		-9.662	
	(0.428)***		(0.333)***	
Latin America	-10.402		-8.526	
	(0.123)***		(0.125)***	
North America	15.157		10.763	
	(0.277)***		(0.185)***	
η	0.954	0.943	0.986	0.959
	(0.006)***	(0.031)***	(0.018)***	(0.051)***
Constant	115.984	88.334	90.542	76.499
	(0.215)***	(0.491)***	(0.204)***	(0.498)***
Observations	5281	1599	5074	1464
R2	0.11	0.09	0.11	0.10

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table II. Predicted Economic Growth and Civil Conflict

	(1) world conflict, SPI	(2) africa conflict, SPI	(3) world conflict, gpcc_ma	(4) africa conflict, gpcc_ma
predicted growth, lagged	-0.098	-0.200	-0.103	-0.148
	(0.049)**	(0.136)	(0.062)*	(0.121)
xpolity, lagged	-0.005	0.063	-0.004	0.066
	(0.032)	(0.054)	(0.031)	(0.056)
polity*growth	0.017	-0.021	0.018	-0.013
	(0.011)	(0.041)	(0.010)*	(0.033)
pop growth	-4.986	14.027	-5.404	17.121
	(7.784)	(7.169)*	(8.110)	(12.058)
log population, lagged	0.225	0.065	0.223	0.066
	(0.075)***	(0.162)	(0.076)***	(0.182)
log gdp/capita, lagged	-0.433	-0.466	-0.464	-0.587
	(0.182)**	(0.420)	(0.193)**	(0.463)
oil	0.630	0.431	0.653	0.482
	(0.298)**	(0.654)	(0.336)*	(0.611)
ethnic fractionalization	0.961	0.460	1.070	0.256
	(0.443)**	(0.756)	(0.656)	(0.658)
mountainous terrain	0.074	0.216	0.045	0.203
	(0.075)	(0.132)	(0.095)	(0.164)
GDP initial	-0.000	0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
North Africa	0.456		0.373	
	(0.541)		(0.575)	
Sub Saharan Africa	-0.298		-0.494	
	(0.607)		(0.618)	
East Asia	-0.466		-0.508	
	(0.422)		(0.495)	
West Asia	0.078		-0.017	
	(0.530)		(0.519)	
Middle East	0.113		0.086	
	(0.664)		(0.731)	
Latin America	0.349		0.334	
	(0.417)		(0.466)	
peace years	-0.050	0.039	-0.042	0.055
	(0.048)	(0.131)	(0.048)	(0.119)
peace years^2	0.004	-0.002	0.003	-0.003
	(0.003)	(0.008)	(0.003)	(0.008)
peace years^3	-0.000	0.000	-0.000	0.000
	(0.000)*	(0.000)	(0.000)	(0.000)
Constant	-2.722	-2.136	-2.368	-1.297
	(1.580)*	(3.206)	(1.907)	(3.944)
Observations	5103	1582	4902	1450
Log likelihood	-518.19	-211.05	-498.83	-195.01
Pseudo R2	0.08	0.05	0.09	0.04

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

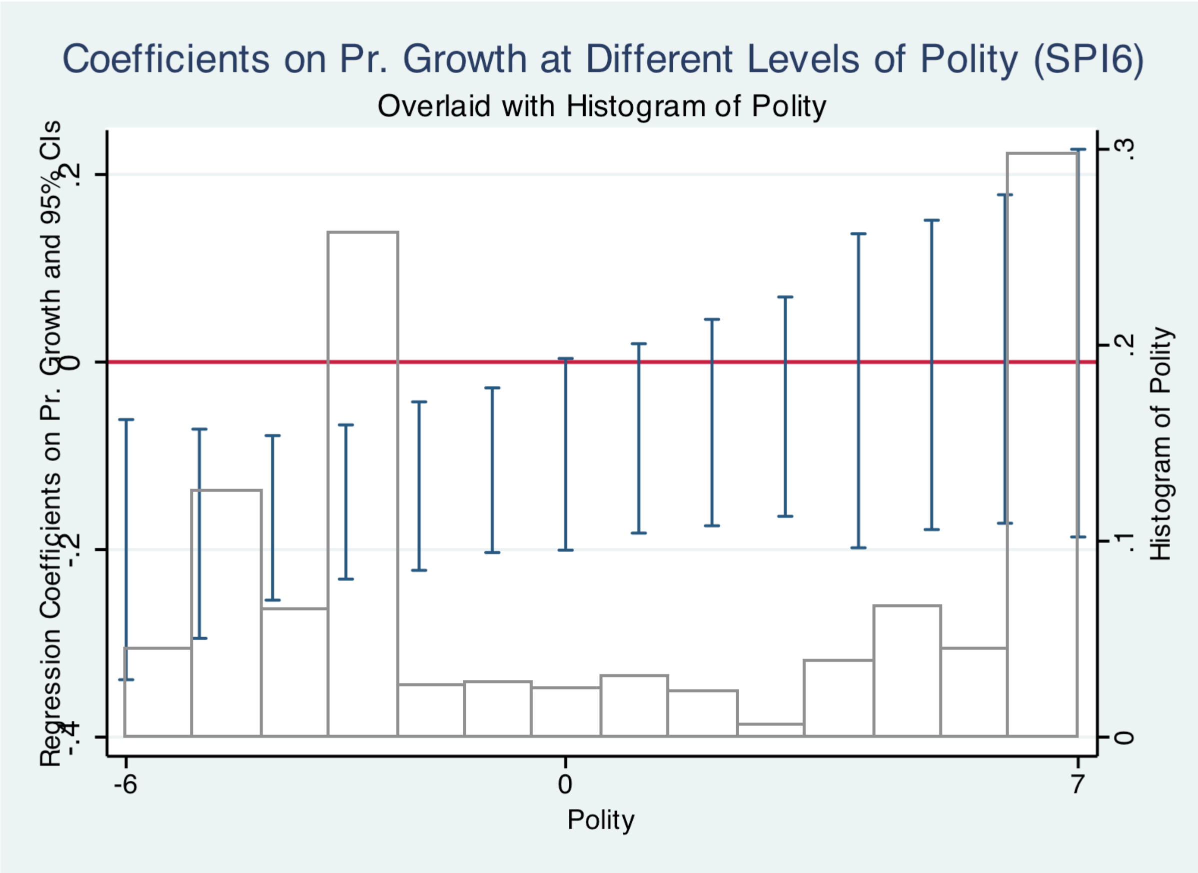

Figure 1. Effects of predicted economic growth on civil conflict at different levels of democracy (SPI 6 in first stage of model)

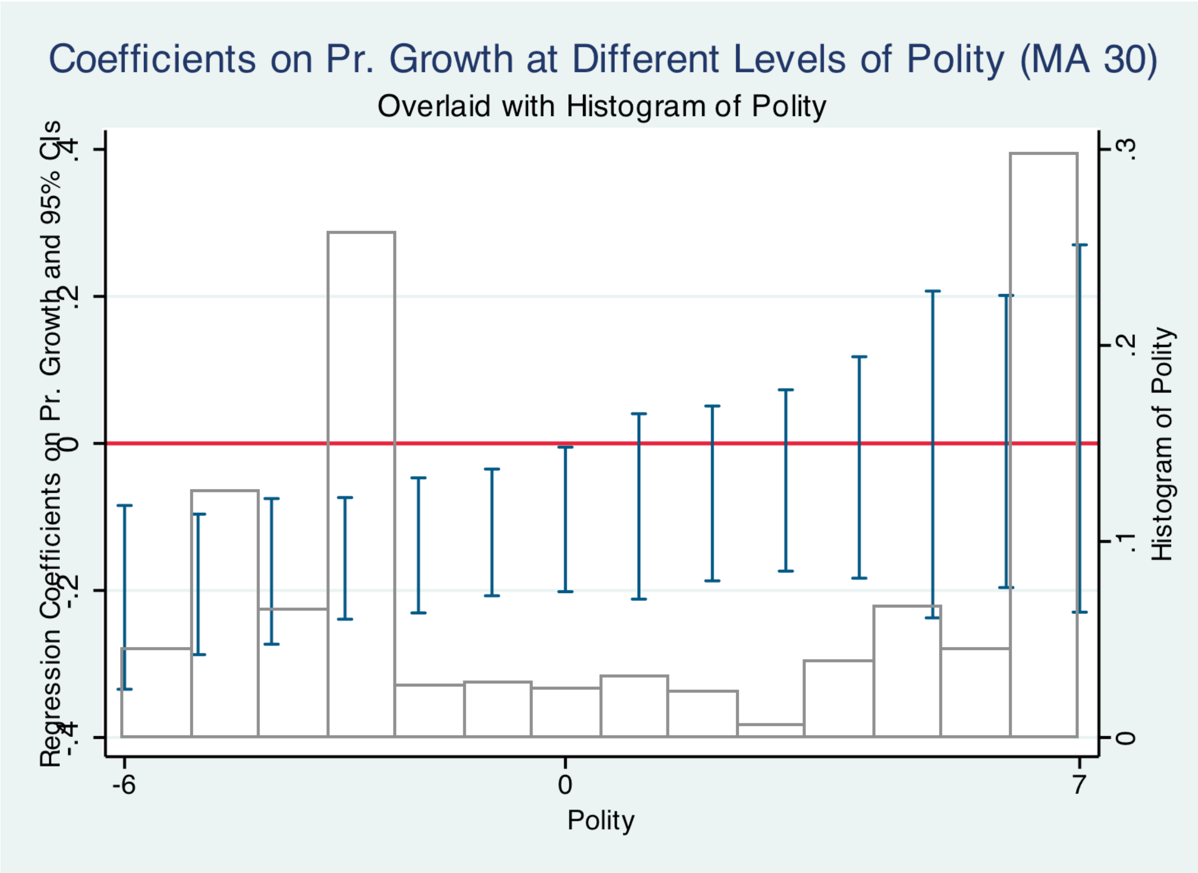

Figure 2. Effects of predicted economic growth on civil conflict at different levels of democracy (MA 30 in first stage of model)

Appendix

Robustness Checks

Table A.I. Climate change and economic growth

	(1)	(2)	(3)	(4)	(5)	(6)
	world growth, gpcc Miguel	africa growth, gpccM	world growth, CRU Miguel	africa growth, CRU Miguel	world growth, CRU_ma	africa growth, CRU_ma
temp_miguel_GPCC	-0.131	-19.572				
	(0.057)**	(11.205)*				
preci_miguel_GPCC	1.068	0.907				
	(0.254)***	(0.563)				
temp_miguel_CRU			0.108	-17.257		
			(0.061)*	(12.974)		
preci_miguel_CRU			1.899	1.144		
			(0.433)***	(0.930)		
temperature ma30					-0.469	-1.078
					(0.219)**	(0.661)
precipitation ma30					0.000	0.002
					(0.001)	(0.002)
xpolity, lagged	-0.033	0.019	-0.067	-0.046	-0.068	-0.059
	(0.034)	(0.077)	(0.031)**	(0.093)	(0.031)**	(0.092)
pop growth	16.001	47.676	18.301	31.131	18.757	31.647
	(14.986)	(53.216)	(10.316)*	(34.333)	(10.217)*	(34.411)
log population, lagged	-4.271	-5.576	-6.983	-5.168	-7.530	-5.071
	(0.688)***	(3.166)*	(0.632)***	(3.053)*	(0.632)***	(3.124)
log gdp/capita, lagged	-5.476	-5.792	-6.207	-6.364	-6.242	-6.204
	(0.967)***	(1.972)***	(0.730)***	(1.470)***	(0.723)***	(1.486)***
trend	0.150	0.154	0.218	0.127	0.235	0.137
	(0.029)***	(0.101)	(0.021)***	(0.089)	(0.023)***	(0.090)
oil	2.842	5.742	3.856	5.467	4.014	5.170
	(0.586)***	(0.393)***	(0.459)***	(0.775)***	(0.450)***	(0.768)***
ethnic fractionalization	-2.419	-1.746	-0.955	0.186	-0.818	0.145
	(0.600)***	(1.297)	(0.558)*	(1.317)	(0.545)	(1.309)
mountainous terrain	0.207	1.744	0.533	1.180	0.620	1.137
	(0.064)***	(0.118)***	(0.069)***	(0.146)***	(0.069)***	(0.143)***
GDP initial	0.000	0.002	0.000	0.002	0.000	0.002
	(0.000)***	(0.000)***	(0.000)	(0.000)***	(0.000)	(0.000)***
North Africa	-5.858		-6.365		-6.093	
	(0.169)***		(0.212)***		(0.198)***	
Sub Saharan Africa	-13.919		-18.352		-18.724	
	(0.431)***		(0.289)***		(0.293)***	
East Asia	-2.313		-2.294		-2.160	
	(0.139)***		(0.378)***		(0.358)***	
West Asia	-5.629		-5.359		-4.919	
	(0.181)***		(0.370)***		(0.378)***	
Middle East	-9.446		-12.851		-13.229	
	(0.333)***		(0.529)***		(0.516)***	
Latin America	-8.332		-10.893		-11.282	
	(0.101)***		(0.131)***		(0.131)***	
North America	10.214		15.020		15.984	
	(0.186)***		(0.324)***		(0.326)***	
η	0.995	0.959	0.968	0.953	0.956	0.952
	(0.021)***	(0.047)***	(0.008)***	(0.038)***	(0.007)***	(0.039)***
Constant	88.173	82.606	117.734	82.847	122.564	81.030
	(0.192)***	(0.494)***	(0.225)***	(0.654)***	(0.241)***	(0.643)***
Observations	5056	1453	4783	1456	4789	1456
R2	0.11	0.10	0.12	0.09	0.12	0.09

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table A.II. Predicted economic growth and civil conflict

	(1)	(2)	(3)	(4)	(5)	(6)
	world conflict, gpcc M	africa conflict, gpcc Miguel	world conflict, CRU Miguel	africa conflict, CRU Miguel	world conflict, CRU_ma	africa conflict, CRU_ma
predicted growth, lagged	-0.119	-0.155	-0.119	-0.193	-0.118	-0.190
	(0.051)**	(0.115)	(0.055)**	(0.137)	(0.044)***	(0.129)
xpolity, lagged	0.003	0.067	0.014	0.064	0.013	0.063
	(0.033)	(0.054)	(0.035)	(0.063)	(0.037)	(0.054)
polity*growth	0.014	-0.013	0.009	-0.023	0.010	-0.021
	(0.011)	(0.030)	(0.011)	(0.037)	(0.011)	(0.041)
pop growth	-5.608	17.053	-5.839	11.150	-5.613	11.145
	(9.242)	(13.241)	(6.967)	(8.134)	(6.082)	(9.122)
log population, lagged	0.223	0.061	0.224	-0.003	0.224	-0.004
	(0.088)**	(0.157)	(0.079)***	(0.154)	(0.066)***	(0.189)
log gdp/capita, lagged	-0.472	-0.645	-0.373	-0.628	-0.373	-0.627
	(0.188)**	(0.376)*	(0.171)**	(0.484)	(0.219)*	(0.505)
oil	0.653	0.511	0.579	0.345	0.580	0.347
	(0.352)*	(0.566)	(0.276)**	(0.674)	(0.307)*	(0.756)
ethnic fractionalization	1.038	0.182	0.829	0.365	0.827	0.367
	(0.592)*	(0.673)	(0.495)*	(0.721)	(0.484)*	(0.741)
mountainous terrain	0.040	0.202	0.070	0.230	0.071	0.232
	(0.085)	(0.141)	(0.100)	(0.145)	(0.083)	(0.164)
GDP_initial	-0.000	0.000	-0.000	0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
North Africa	0.341		0.489		0.492	
	(0.628)		(0.681)		(0.700)	
Sub Saharan Africa	-0.529		-0.097		-0.096	
	(0.638)		(0.646)		(0.641)	
East Asia	-0.512		-0.316		-0.316	
	(0.441)		(0.602)		(0.587)	
West Asia	-0.036		0.290		0.292	
	(0.524)		(0.554)		(0.683)	
Middle East	0.089		0.415		0.416	
	(0.738)		(0.762)		(0.666)	
Latin America	0.293		0.439		0.444	
	(0.467)		(0.574)		(0.540)	
peace years	-0.039	0.059	-0.040	0.040	-0.041	0.041
	(0.050)	(0.115)	(0.045)	(0.117)	(0.051)	(0.146)
peace years^2	0.003	-0.003	0.003	-0.003	0.003	-0.003
	(0.003)	(0.007)	(0.003)	(0.007)	(0.003)	(0.009)
peace years^3	-0.000	0.000	-0.000	0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-2.220	-0.844	-3.145	-0.329	-3.162	-0.325
	(1.828)	(3.127)	(1.808)*	(3.651)	(2.039)	(3.552)
Observations	4885	1440	4682	1456	4688	1456
Log likelihood	-498.09	-194.55	-496.00	-197.81	-496.09	-197.81
Pseudo R2	0.09	0.04	0.08	0.05	0.08	0.05

(Bootstrapped) standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Tables A.I and A.II show the robustness check of our results for different indicators of climate change and different data sources. The coefficients shown in columns (1) to (4) rely on climate change as defined by Miguel; columns (1) and (2) are based on the GPCC data and columns (3) and (4) rely on the CRU data. Columns (5) and (6) replicate the results for a moving average, this time based on the CRU data rather than on the GPCC data as in the main text.

Table A.III. Climate change and economic growth, bottom billion

	(1)	(2)
	bottom billion growth, SPI	bottom billion growth, gpcc_ma
SPI	-1.401	
	(1.024)	
temperature ma30		-0.320
		(0.622)
precipitation ma30		0.003
		(0.002)
xpolity, lagged	0.054	0.072
	(0.081)	(0.083)
pop growth	17.873	29.039
	(22.799)	(33.925)
log population, lagged	-0.772	-0.524
	(0.845)	(1.136)
log gdp/capita, lagged	-8.099	-8.079
	(1.664)***	(2.315)***
oil	0.931	0.411
	(1.420)	(1.507)
ethnic fractionalization	-1.197	-1.502
	(1.496)	(2.021)
mountainous terrain	-0.291	-0.453
	(0.155)*	(0.141)***
GDP initial	0.004	0.004
	(0.000)***	(0.000)***
η	0.973	0.983
	(0.110)***	(0.112)***
Constant	60.555	58.458
	(0.807)***	(0.862)***
Observations	1512	1382
R-squared	0.08	0.08
R2	0.08	0.08

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table A.IV. Predicted economic growth and conflict, bottom billion

	(1)	(2)
	bottom billion conflict, SPI	bottom billion conflict, gpcc_ma
predicted growth, lagged	-0.118	-0.172
	(0.094)	(0.123)
xpolity, lagged	0.035	0.053
	(0.051)	(0.046)
polity*growth	0.011	0.004
	(0.027)	(0.034)
pop growth	11.401	13.492
	(5.569)**	(9.312)
log population, lagged	0.123	0.127
	(0.187)	(0.201)
log gdp/capita, lagged	-0.989	-1.323
	(0.446)**	(0.540)**
oil	0.473	0.487
	(0.735)	(0.733)
ethnic fractionalization	0.052	-0.025
	(0.676)	(0.718)
mountainous terrain	0.061	0.017
	(0.168)	(0.135)
GDP initial	0.000	0.000
	(0.000)	(0.000)
peace years	-0.031	-0.006
	(0.098)	(0.096)
peace years^2	0.003	0.002
	(0.005)	(0.005)
peace years^3	-0.000	-0.000
	(0.000)	(0.000)
Constant	1.416	3.576
	(3.312)	(4.109)
Observations	1496	1368
Log likelihood	-204.04	-185.95
Pseudo R2	0.04	0.04
Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%		

Further, tables A.III and A.IV replicate the main analyses for the subsample of "bottom billion" countries as defined by Buhaug et al. (2010), relying on the concept of Collier (2007).

Table A.V. Climate change and economic growth – 1000 battle related deaths

	(1)	(2)
	world, gpcc_ma	africa, gpcc ma
temperature ma30	-0.203	-0.856
	(0.189)	(0.475)*
precipitation ma30	0.000	0.002
	(0.001)	(0.002)
xpolity, lagged	-0.036	0.008
	(0.033)	(0.076)
pop growth	15.965	48.524
	(15.011)	(53.879)
log population, lagged	-4.613	-4.933
	(0.690)***	(3.317)
log gdp/capita, lagged	-5.417	-5.579
	(0.960)***	(1.967)***
trend	0.158	0.146
	(0.029)***	(0.103)
oil	2.925	4.845
	(0.574)***	(0.391)***
ethnic fractionalization	-2.237	-2.093
	(0.606)***	(1.313)
mountainous terrain	0.265	1.471
	(0.065)***	(0.105)***
GDP_initial	0.000	0.002
	(0.000)***	(0.000)***
North Africa	-5.570	
	(0.182)***	
Sub Saharan Africa	-14.109	
	(0.429)***	
East Asia	-2.165	
	(0.151)***	
West Asia	-5.247	
	(0.185)***	
Middle East	-9.662	
	(0.333)***	
Latin America	-8.526	
	(0.125)***	
North America	10.763	
	(0.185)***	
η	0.986	0.959
	(0.018)***	(0.051)***
Constant	90.542	76.499
	(0.204)***	(0.498)***
Observations	5074	1464
R2	0.11	0.10
Standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%		

Table A.VI. Predicted economic growth and civil conflict – 1000 battle related deaths

	(1)	(2)
	world conflict, gpcc_ma	africa conflict, gpcc_ma
predicted growth, lagged	-0.188	-0.148
	(0.063)***	(0.093)
xpolity, lagged	-0.054	0.066
	(0.054)	(0.063)
polity*growth	0.024	-0.013
	(0.015)	(0.026)
pop growth	-7.317	17.121
	(11.300)	(10.594)
log population, lagged	0.239	0.066
	(0.095)**	(0.129)
log gdp/capita, lagged	-0.722	-0.587
	(0.251)***	(0.506)
oil	0.591	0.482
	(0.656)	(0.690)
ethnic fractionalization	1.135	0.256
	(0.745)	(0.608)
mountainous terrain	0.132	0.203
	(0.166)	(0.183)
GDP_initial	-0.000	0.000
	(0.000)	(0.000)
North Africa	-0.212	
	(2.387)	
Sub Saharan Africa	-1.290	
	(2.296)	
East Asia	-0.209	
	(2.171)	
West Asia	-0.361	
	(2.283)	
Middle East	0.471	
	(2.266)	
Latin America	0.665	
	(2.128)	
peace years	-0.074	0.055
	(0.077)	(0.127)
peace years^2	0.006	-0.003
	(0.005)	(0.008)
peace years^3	-0.000	0.000
	(0.000)	(0.000)
Constant	-0.972	-1.297
	(2.774)	(3.736)
Observations	4902	1450
Log likelihood	-282.02	-195.01
Pseudo R2	0.13	0.04
Standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%		

Tables A.V and A.VI provide the results if we replace the conflict onset indicator with the measurement that relies on a total of 1000 instead of battle related deaths.

Descriptive Statistics

Table A.VII. Descriptive statistics, world

Variable		Mean	Std. Dev.	Min	Max	Observations
Economic growth	overall	2.017	7.520	-63.319	151.065	N = 6275
	between		1.988			n = 171
	within		7.301			T = 36.700
Civil conflict	overall	.0217	.146	0	1	N = 8568
	between		.031			n = 191
	within		.143			T-bar = 44.859
SPI	overall	.076	.265	0	1	N = 8568
	between		.078			n = 191
	within		.255			T-bar = 44.8586
Temperature ma30 GPCC	overall	.186	.592	-3.979	4.557	N = 7084
	between		.194			n = 163
	within		.566			T-bar = 43.4601
Precipitation ma30 GPCC	overall	-17.715	188.597	-1310.04	3728.213	N = 7333
	between		50.755			n = 166
	within		182.962			T-bar = 44.1747
Temperature ma30 CRU	overall	.101	.484	-2.26	2.273	N = 6884
	between		.109			n = 179
	within		.474			T = 38.4581
Precipitation ma30 CRU	overall	-9.108	178.984	-1247.274	1523.063	N = 6884
	between		45.025			n = 179
	within		175.651			T = 38.4581
Temperature Miguel GPCC	overall	.002	.590	-20	35	N = 6878
	between		.073			n = 162
	within		.585			T = 42.4568
Precipitation Miguel GPCC	overall	.032	.294	-.932	4.2	N = 7168
	between		.063			n = 165
	within		.288			T = 43.4424
Temperature Miguel CRU	overall	.009	.421	-13	20	N = 6881
	between		.060			n = 179
	within		.415			T = 38.441
Precipitation Miguel CRU	overall	.024	.247	-.838	3.323	N = 6884
	between		.050			n = 179
	within		.243			T = 38.458
xpolity, lagged	overall	.857	4.922	-6	7	N = 7179
	between		4.122			n = 155
	within		2.768			T-bar = 46.316
pop growth	overall	.0186	.026	-.563	1.050	N = 7346
	between		.013			n = 183
	within		.023			T-bar = 40.142

log population, lagged	overall	8.682	1.898	2.812	14.074	N = 7529
	between		2.062			n = 183
	within		.312			T-bar = 41.142
log gdp/capita, lagged	overall	8.252	1.119	5.139	11.343	N = 7525
	between		1.065			n = 183
	within		.367			T-bar = 41.120
oil	overall	.134	.341	0	1	N = 7449
	between		.316			n = 150
	within		.153			T-bar = 49.66
ethnic fractionalization	overall	.385	.281	.001	.925	N = 7449
	between		.274			n = 150
	within		.020			T-bar = 49.66
mountainous terrain	overall	2.136	1.424	0	4.557	N = 7449
	between		1.451			n = 150
	within		.031			T-bar = 49.66
GDP initial	overall	4328.217	7559.614	233.01	72213.92	N = 8049
	between		8164.048			n = 183
	within		0			T-bar = 43.984
North Africa	overall	.038	.190	0	1	N = 8568
	between		.175			n = 191
	within		0			T-bar = 44.859
Sub Saharan Africa	overall	.220	.414	0	1	N = 8568
	between		.419			n = 191
	within		0			T-bar = 44.859
East Asia	overall	.127	.333	0	1	N = 8568
	between		.326			n = 191
	within		0			T-bar = 44.859
West Asia	overall	.059	.236	0	1	N = 8568
	between		.253			n = 191
	within		0			T-bar = 44.859
Middle East	overall	.084	.277	0	1	N = 8568
	between		.261			n = 191
	within		0			T-bar = 44.859
Latin America	overall	.184	.387	0	1	N = 8568
	between		.370			n = 191
	within		0			T-bar = 44.859
North America	overall	.015	.120	0	1	N = 8568
	between		.102			n = 191
	within		0			T-bar = 44.859
trend	overall	26.713	17.099	1	63	N = 8568
	between		9.237			n = 191
	within		15.647			T-bar = 44.859

Table A.VIII. Descriptive statistics, Africa

Variable		Mean	Std. Dev.	Min	Max	Observations
Economic growth	overall	1.414	9.863	-63.319	151.065	N = 1930
	between		2.170			n = 56
	within		9.674			T = 34.464
Civil conflict	overall	.032	.175	0	1	N = 2365
	between		.031			n = 59
	within		.173			T = 40.085
SPI	overall	.077	.266	0	1	N = 2365
	between		.063			n = 59
	within		.259			T = 40.085
Temperature ma30 GPCC	overall	.128	.517	-2.433	1.981	N = 2116
	between		.144			n = 57
	within		.496			T = 37.123
Precipitation ma30 GPCC	overall	-25.288	128.695	-707.317	918.371	N = 2198
	between		32.005			n = 59
	within		124.530			T = 37.254
Temperature ma30 CRU	overall	.129	.435	-1.825	1.686	N = 2283
	between		.098			n = 58
	within		.425			T = 39.362
Precipitation ma30 CRU	overall	-20.243	128.914	-867.013	1301.607	N = 2283
	between		28.686			n = 58
	within		125.843			T = 39.362
Temperature Miguel GPCC	overall	.001	.027	-.142	.113	N = 2110
	between		.001			n = 57
	within		.027			T = 37.018
Precipitation Miguel GPCC	overall	.0520	.391	-.932	4.2	N = 2197
	between		.096			n = 59
	within		.382			T = 37.237
Temperature Miguel CRU	overall	.001	.026	-.197	.176	N = 2283
	between		.001			n = 58
	within		.026			T = 39.362
Precipitation Miguel CRU	overall	.037	.306	-.838	3.021	N = 2283
	between		.063			n = 58
	within		.301			T = 39.362
xpolity, lagged	overall	-1.676	4.042	-6	7	N = 2280
	between		3.341			n = 59
	within		2.217			T = 38.644
pop growth	overall	.028	.027	-.555	.486	N = 2247
	between		.011			n = 59
	within		.026			T = 38.085

log population, lagged	overall	8.556	1.279	5.418	11.699	N = 2306
	between		1.237			n = 59
	within		.355			T = 39.085
log gdp/capita, lagged	overall	7.671	1.089	5.139	11.081	N = 2247
	between		1.081			n = 59
	within		.300			T = 38.085
oil	overall	.242	.429	0	1	N = 2365
	between		.379			n = 59
	within		.192			T = 40.085
ethnic fractionalization	overall	.486	.296	.036	.925	N = 2365
	between		.289			n = 59
	within		.001			T = 40.085
mountainous terrain	overall	1.802	1.453	0	4.421	N = 2365
	between		1.451			n = 59
	within		0			T = 40.085
GDP initial	overall	3370.897	8442.823	330.67	64913.51	N = 2306
	between		8554.005			n = 59
	within		0			T = 39.085
trend	overall	21.906	13.441	1	55	N = 2365
	between		5.272			n = 59
	within		12.637			T = 40.085

Binary Correlations

Table A.IX. Binary correlations, World

	growth	conflict	SPI	temp_ma_30_GPCC	preci_ma_30_GPCC	temp_ma30_CRU	preci_ma30_CRU	temp_miguel_GPCC	preci_miguel_GPCC	temp_miguel_CRU	preci_miguel_CRU	xpolity, lagged	pop growth	log population, lagged
growth	1.00													
conflict	-0.03	1.00												
	(0.04)													
SPI	-0.02	-0.01	1.00											
	(0.15)	(0.25)												
temp_ma_30_GPCC	-0.01	-0.02	0.00	1.00										
	(0.27)	(0.05)	(0.76)											
preci_ma_30_GPCC	0.02	-0.01	-0.03	-0.06	1.00									
	(0.19)	(0.36)	(0.02)	(0.00)										
temp_ma30_CRU	-0.04	-0.00	0.02	0.80	-0.04	1.00								
	(0.01)	(0.91)	(0.04)	(0.00)	(0.00)									
preci_ma30_CRU	0.03	-0.01	-0.02	-0.07	0.69	-0.08	1.00							
	(0.02)	(0.21)	(0.09)	(0.00)	(0.00)	(0.00)								
temp_miguel_GPCC	-0.01	0.00	0.01	0.00	-0.00	0.05	-0.00	1.00						
	(0.32)	(0.98)	(0.51)	(0.78)	(0.85)	(0.00)	(0.83)							
preci_miguel_GPCC	0.04	-0.01	-0.00	-0.05	0.42	-0.05	0.32	-0.00	1.00					
	(0.00)	(0.33)	(0.78)	(0.00)	(0.00)	(0.00)	(0.00)	(0.84)						
temp_miguel_CRU	0.01	-0.00	-0.00	0.07	0.01	0.08	0.01	-0.02	-0.01	1.00				
	(0.52)	(0.74)	(0.79)	(0.00)	(0.58)	(0.00)	(0.55)	(0.11)	(0.62)					
preci_miguel_CRU	0.05	-0.01	-0.01	-0.07	0.36	-0.07	0.47	-0.00	0.72	-0.00	1.00			
	(0.00)	(0.57)	(0.54)	(0.00)	(0.00)	(0.00)	(0.00)	(0.79)	(0.00)	(0.89)				
xpolity, lagged	0.04	-0.02	0.00	0.04	0.01	0.02	0.03	0.01	-0.04	0.03	-0.03	1.00		
	(0.01)	(0.05)	(1.00)	(0.00)	(0.28)	(0.06)	(0.01)	(0.27)	(0.00)	(0.02)	(0.02)			
pop growth	-0.04	0.01	-0.00	-0.01	-0.01	-0.02	-0.01	-0.00	0.02	-0.02	0.03	-0.22	1.00	
	(0.00)	(0.45)	(0.93)	(0.64)	(0.55)	(0.14)	(0.39)	(0.81)	(0.21)	(0.16)	(0.01)	(0.00)		
log population, lagged	-0.01	0.07	-0.00	0.02	0.03	0.00	0.04	0.02	-0.05	0.00	-0.04	0.11	-0.02	1.00

	(0.67)	(0.00)	(1.00)	(0.12)	(0.02)	(0.90)	(0.00)	(0.09)	(0.00)	(0.90)	(0.00)	(0.00)	(0.12)	
log GDP/capita, lagged	0.01	-0.08	-0.01	0.06	0.04	0.03	0.04	0.01	0.04	0.04	0.04	0.42	-0.14	-0.14
	(0.25)	(0.00)	(0.34)	(0.00)	(0.00)	(0.02)	(0.00)	(0.30)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
oil	-0.01	0.03	-0.01	-0.01	0.01	0.04	0.02	0.02	0.06	-0.00	0.04	-0.23	0.11	-0.04
	(0.34)	(0.00)	(0.56)	(0.36)	(0.41)	(0.00)	(0.19)	(0.10)	(0.00)	(0.93)	(0.00)	(0.00)	(0.00)	(0.00)
ethnic fractionalization	-0.07	0.07	0.05	0.04	-0.06	0.01	-0.06	-0.00	-0.03	-0.02	-0.02	-0.13	0.08	0.04
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.34)	(0.00)	(0.93)	(0.01)	(0.09)	(0.07)	(0.00)	(0.00)	(0.00)
mountainous terrain	0.01	0.04	-0.00	-0.01	0.03	-0.01	0.02	0.00	-0.03	-0.02	-0.03	-0.05	-0.00	0.28
	(0.66)	(0.00)	(0.85)	(0.48)	(0.03)	(0.63)	(0.12)	(0.71)	(0.03)	(0.11)	(0.01)	(0.00)	(0.96)	(0.00)
GDP initial	-0.04	-0.04	0.00	0.01	0.02	0.01	0.02	0.00	0.07	0.01	0.10	0.01	0.07	-0.23
	(0.00)	(0.00)	(0.74)	(0.29)	(0.04)	(0.24)	(0.17)	(0.72)	(0.00)	(0.35)	(0.00)	(0.56)	(0.00)	(0.00)
North Africa	0.01	0.01	-0.01	0.04	0.00	0.04	-0.00	-0.00	0.03	-0.00	0.00	-0.18	0.05	0.08
	(0.69)	(0.24)	(0.35)	(0.00)	(0.72)	(0.00)	(0.88)	(0.99)	(0.01)	(0.77)	(0.81)	(0.00)	(0.00)	(0.00)
Sub Saharan Africa	-0.07	0.02	0.05	-0.01	-0.08	0.03	-0.06	-0.00	-0.02	-0.01	-0.01	-0.21	0.13	-0.12
	(0.00)	(0.05)	(0.00)	(0.62)	(0.00)	(0.01)	(0.00)	(0.93)	(0.09)	(0.39)	(0.40)	(0.00)	(0.00)	(0.00)
East Asia	0.04	0.01	0.03	0.01	0.03	0.02	-0.02	-0.02	-0.02	-0.03	-0.02	0.02	0.03	0.17
	(0.00)	(0.33)	(0.00)	(0.29)	(0.01)	(0.14)	(0.09)	(0.09)	(0.04)	(0.01)	(0.09)	(0.14)	(0.00)	(0.00)
West Asia	0.01	0.04	0.01	0.08	0.00	-0.00	0.01	0.00	-0.01	-0.00	-0.01	-0.03	0.01	0.15
	(0.66)	(0.00)	(0.35)	(0.00)	(0.80)	(0.71)	(0.46)	(0.90)	(0.60)	(0.94)	(0.53)	(0.01)	(0.24)	(0.00)
Middle East	-0.01	0.02	-0.03	-0.04	0.02	0.02	0.01	-0.00	0.12	-0.01	0.10	-0.25	0.20	-0.08
	(0.45)	(0.15)	(0.01)	(0.00)	(0.13)	(0.04)	(0.29)	(0.96)	(0.00)	(0.67)	(0.00)	(0.00)	(0.00)	(0.00)
Latin America	-0.02	-0.01	0.00	-0.05	0.02	-0.01	0.00	-0.00	-0.02	-0.01	-0.02	0.08	-0.00	-0.16
	(0.14)	(0.43)	(0.93)	(0.00)	(0.10)	(0.52)	(0.94)	(0.93)	(0.09)	(0.42)	(0.16)	(0.00)	(0.75)	(0.00)
North America	0.00	-0.02	0.01	0.04	0.01	0.01	0.01	0.00	-0.01	-0.00	-0.01	0.16	-0.02	0.16
	(0.84)	(0.09)	(0.40)	(0.00)	(0.22)	(0.45)	(0.34)	(0.72)	(0.27)	(1.00)	(0.31)	(0.00)	(0.05)	(0.00)
trend	-0.04	-0.03	0.05	0.21	-0.04	0.24	-0.01	0.01	-0.02	0.00	-0.02	0.25	-0.09	0.38
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.63)	(0.41)	(0.15)	(0.73)	(0.15)	(0.00)	(0.00)	(0.00)

	lag GDP/capita, lagged	Oil	ethnic fraction-alization	moun-tainous terrain	GDP initial	North Africa	Sub Saharan Africa	East Asia	West Asia	Middle East	Latin America	North America	trend
log GDP/capita, lagged	1.00												
oil	0.15	1.00											
	(0.00)												
ethnic fractionalization	-0.40	0.03	1.00										
	(0.00)	(0.03)											
mountainous terrain	-0.15	-0.04	-0.04	1.00									
	(0.00)	(0.00)	(0.00)										
GDP initial	0.52	0.24	-0.18	-0.19	1.00								
	(0.00)	(0.00)	(0.00)	(0.00)									
North Africa	-0.03	0.18	-0.03	-0.01	-0.03	1.00							
	(0.02)	(0.00)	(0.00)	(0.26)	(0.00)								
Sub Saharan Africa	-0.49	-0.07	0.49	-0.25	-0.21	-0.10	1.00						
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)							
East Asia	-0.10	-0.10	0.00	0.10	-0.06	-0.08	-0.20	1.00					
	(0.00)	(0.00)	(0.76)	(0.00)	(0.00)	(0.00)	(0.00)						
West Asia	-0.20	-0.05	0.20	0.21	-0.09	-0.05	-0.13	-0.10	1.00				
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)					
Middle East	0.13	0.41	-0.18	-0.00	0.32	-0.06	-0.16	-0.12	-0.08	1.00			
	(0.00)	(0.00)	(0.00)	(0.91)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)				
Latin America	0.11	-0.02	-0.20	0.16	-0.03	-0.09	-0.25	-0.18	-0.12	-0.14	1.00		
	(0.00)	(0.18)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)			
North America	0.17	-0.05	0.08	0.08	0.10	-0.02	-0.06	-0.05	-0.03	-0.04	-0.06	1.00	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
trend	0.24	0.02	-0.09	0.08	-0.06	0.01	-0.10	0.02	-0.03	0.02	0.04	0.04	1.00
	(0.00)	(0.05)	(0.00)	(0.00)	(0.00)	(0.35)	(0.00)	(0.03)	(0.02)	(0.06)	(0.00)	(0.00)	

Table A.X. Binary correlations, Africa

	growth	conflict	SPI	temp_ma_30_GPCC	preci_ma_30_GPCC	temp_ma30_CRU	preci_ma30_CRU	temp_miguel_GPCC	preci_miguel_GPCC	temp_miguel_CRU	preci_miguel_CRU	xpolity,lagged	pop growth	log population, lagged
growth	1.00													
conflict	-0.03	1.00												
	(0.04)													
SPI	-0.02	-0.01	1.00											
	(0.15)	(0.25)												
temp_ma_30_GPCC	-0.01	-0.02	0.00	1.00										
	(0.27)	(0.05)	(0.76)											
preci_ma_30_GPCC	0.02	-0.01	-0.03	-0.06	1.00									
	(0.19)	(0.36)	(0.02)	(0.00)										
temp_ma30_CRU	-0.04	-0.00	0.02	0.80	-0.04	1.00								
	(0.01)	(0.91)	(0.04)	(0.00)	(0.00)									
preci_ma30_CRU	0.03	-0.01	-0.02	-0.07	0.69	-0.08	1.00							
	(0.02)	(0.21)	(0.09)	(0.00)	(0.00)	(0.00)								
temp_miguel_GPCC	-0.01	0.00	0.01	0.00	-0.00	0.05	-0.00	1.00						
	(0.32)	(0.98)	(0.51)	(0.78)	(0.85)	(0.00)	(0.83)							
preci_miguel_GPCC	0.04	-0.01	-0.00	-0.05	0.42	-0.05	0.32	-0.00	1.00					
	(0.00)	(0.33)	(0.78)	(0.00)	(0.00)	(0.00)	(0.00)	(0.84)						
temp_miguel_CRU	0.01	-0.00	-0.00	0.07	0.01	0.08	0.01	-0.02	-0.01	1.00				
	(0.52)	(0.74)	(0.79)	(0.00)	(0.58)	(0.00)	(0.55)	(0.11)	(0.62)					
preci_miguel_CRU	0.05	-0.01	-0.01	-0.07	0.36	-0.07	0.47	-0.00	0.72	-0.00	1.00			
	(0.00)	(0.57)	(0.54)	(0.00)	(0.00)	(0.00)	(0.00)	(0.79)	(0.00)	(0.89)				
xpolity, lagged	0.04	-0.02	0.00	0.04	0.01	0.02	0.03	0.01	-0.04	0.03	-0.03	1.00		
	(0.01)	(0.05)	(1.00)	(0.00)	(0.28)	(0.06)	(0.01)	(0.27)	(0.00)	(0.02)	(0.02)			
pop growth	-0.04	0.01	-0.00	-0.01	-0.01	-0.02	-0.01	-0.00	0.02	-0.02	0.03	-0.22	1.00	
	(0.00)	(0.45)	(0.93)	(0.64)	(0.55)	(0.14)	(0.39)	(0.81)	(0.21)	(0.16)	(0.01)	(0.00)		

log population, lagged	-0.01	0.07	-0.00	0.02	0.03	0.00	0.04	0.02	-0.05	0.00	-0.04	0.11	-0.02	1.00
	(0.67)	(0.00)	(1.00)	(0.12)	(0.02)	(0.90)	(0.00)	(0.09)	(0.00)	(0.90)	(0.00)	(0.00)	(0.12)	
log GDP/capita, lagged	0.01	-0.08	-0.01	0.06	0.04	0.03	0.04	0.01	0.04	0.04	0.04	0.42	-0.14	-0.14
	(0.25)	(0.00)	(0.34)	(0.00)	(0.00)	(0.02)	(0.00)	(0.30)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
oil	-0.01	0.03	-0.01	-0.01	0.01	0.04	0.02	0.02	0.06	-0.00	0.04	-0.23	0.11	-0.04
	(0.34)	(0.00)	(0.56)	(0.36)	(0.41)	(0.00)	(0.19)	(0.10)	(0.00)	(0.93)	(0.00)	(0.00)	(0.00)	(0.00)
ethnic fractionalization	-0.07	0.07	0.05	0.04	-0.06	0.01	-0.06	-0.00	-0.03	-0.02	-0.02	-0.13	0.08	0.04
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.34)	(0.00)	(0.93)	(0.01)	(0.09)	(0.07)	(0.00)	(0.00)	(0.00)
mountainous terrain	0.01	0.04	-0.00	-0.01	0.03	-0.01	0.02	0.00	-0.03	-0.02	-0.03	-0.05	-0.00	0.28
	(0.66)	(0.00)	(0.85)	(0.48)	(0.03)	(0.63)	(0.12)	(0.71)	(0.03)	(0.11)	(0.01)	(0.00)	(0.96)	(0.00)
GDP initial	-0.04	-0.04	0.00	0.01	0.02	0.01	0.02	0.00	0.07	0.01	0.10	0.01	0.07	-0.23
	(0.00)	(0.00)	(0.74)	(0.29)	(0.04)	(0.24)	(0.17)	(0.72)	(0.00)	(0.35)	(0.00)	(0.56)	(0.00)	(0.00)
trend	-0.04	-0.03	0.05	0.21	-0.04	0.24	-0.01	0.01	-0.02	0.00	-0.02	0.25	-0.09	0.38
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.63)	(0.41)	(0.15)	(0.73)	(0.15)	(0.00)	(0.00)	(0.00)

	pop growth	log population, lagged	log GDP/ capita, lagged	oil	ethnic fractionalization	mountainous terrain	GDP_initial	trend
pop growth	1.00							
log population	-0.07	1.00						
	(0.00)							
log GDP/ capita, lagged	0.17	-0.29	1.00					
	(0.00)	(0.00)						
oil	0.13	0.06	0.44	1.00				
	(0.00)	(0.01)	(0.00)					
ethnic fractionalization	-0.06	0.22	-0.39	-0.17	1.00			
	(0.00)	(0.00)	(0.00)	(0.00)				
mountainous terrain	-0.10	0.36	-0.13	-0.03	-0.32	1.00		
	(0.00)	(0.00)	(0.00)	(0.14)	(0.00)			
GDP initial	0.18	-0.25	0.55	0.32	-0.22	-0.19	1.00	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
trend	-0.02	0.40	0.13	0.12	-0.08	0.10	-0.02	1.00
	(0.28)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.32)	